# BROOKHAVEN NATIONAL LABORATORY
# LASER CONTROLLED AREA
# STANDARD OPERATING PROCEDURE (SOP)

This document defines the safety management program for the laser system listed below. All American National Standard Institute (ANSI) Hazard Class 3b and 4 laser systems must be documented, reviewed, and approved through use of this form. Each system must be reviewed annually.

| |
|---|
| *System description:* Stochastic Cooling Electro-Optical Delay Line Filter |
| *Location:*1004B and 1012 |

## LINE MANAGEMENT RESPONSIBILITIES

The Owner/Operator for this laser is listed below. The Owner/Operator is the Line Manager of the system and must ensure that work with this laser conforms to the guidance outlined in this form.

**Owner/Operator:**

Signature on File

*Name:* M. Brennan *Signature:* *Date:* 1-4-07

## AUTHORIZATION

Work with all ANSI Class 3b and 4 laser systems must be planned and documented with this form. Laser system operators must understand and conform to the guidelines contained in this document. This form must be completed, reviewed, and approved before laser operations begin. The following signatures are required.

| *BNL LSO printed name* | *Signature* | *Date* |
|---|---|---|
| C. Weilandics | Signature on File | 1-8-07 |
| A. Etkin | Signature on File | 11-10-07 |

| *Department ES&H Approval printed name* | *Signature* | *Date* |
|---|---|---|

| APPLICABLE LASER OPERATIONS |
|---|
| Operation Maintenance Service Specific Operation ☒ Fiber Optics |
| |

# LASER SYSTEM HAZARD ANALYSIS

Hazard analysis requires information about the laser system characteristics and the configuration of the beam distribution system. The analysis includes both laser (light) and non-laser hazards. A Nominal Hazard Zone (NHZ) analysis must be completed to aid in the identification of appropriate controls.

| LASER SYSTEM CHARACTERISTICS | | | | | |
|---|---|---|---|---|---|
| Laser Type *(Argon, $CO_2$, etc.)* | Wavelengths | ANSI Class | Maximum Power or Energy/Pulse | Pulse Length | Repetition Rate |
| Erbium Doped Fiber Amplifier | 1530nm to 1565nm | IV | +27dBm | CW | NA |

☐ **Cryogen Use**

Describe type, quantity, and use.

none

☐ **Chemicals & Compressed Gasses**

Describe type, quantity, and use.

none

☐ **Electrical Hazards**

Description *(Describe the power supply to the system).*

none

☐ **Other Special Equipment**

Description *(Equipment used with the laser[s]).*

none

**Laser System Configuration**: Describe the system controls *(keys, switch panels, computer controls),* beam path, and optics *(provide a functional/block diagram for complicated beam paths)*.

Stochastic cooling is being installed in RHIC in order to preserve the longitudinal size of the stored beam and increase the average luminosity. The system has a beam pickup electrode at 1012 at y011-q4, the output of which is connected to electro-optical transmitter. The modulated light is connected to the optical delay-line filter and beam kicker, located in 1004 and 1004A by optical fiber cable. The pickup signal will be shaped by the filter and drive the longitudinal beam kicker.

The stochastic cooling project for RHIC will use a fiber optic network in the low-level processing electronics. By using light to realize the processing function, the problem of dispersion in coaxial cables is eliminated, and because the bandwidth of the system extends to 8 GHz and beyond, this feature of fiber optic networks is very beneficial. One component of the network is an Erbium-Doped Fiber Amplifier that is capable of producing 500mW of optical power.

The components of the entire system consist of; the EDFA, an optical modulator, optical splitters, variable delay adjusters, and fiber optic-to electrical receiver and transmitter. The arrangement is shown in figure 1. The components are interconnected via fiber optic cable, that is either fusion spliced together or connectorized with standard connector series, such as, E2000/APC or SC/APC connectors. An important feature of these connectors is that they contain automatic shutters that close whenever the connectors are disengaged on both plugs and sockets. There are no free-space light paths from which light could be viewed or scattered. When the system is in operation all the optical connections are made up and the adjustments are made via the delay adjusters or the electrical signals sent to the modulator and the transmitter. When it becomes operational for the stochastic cooling system development it will be contained in a typical 19-inch rack-mounted enclosure.

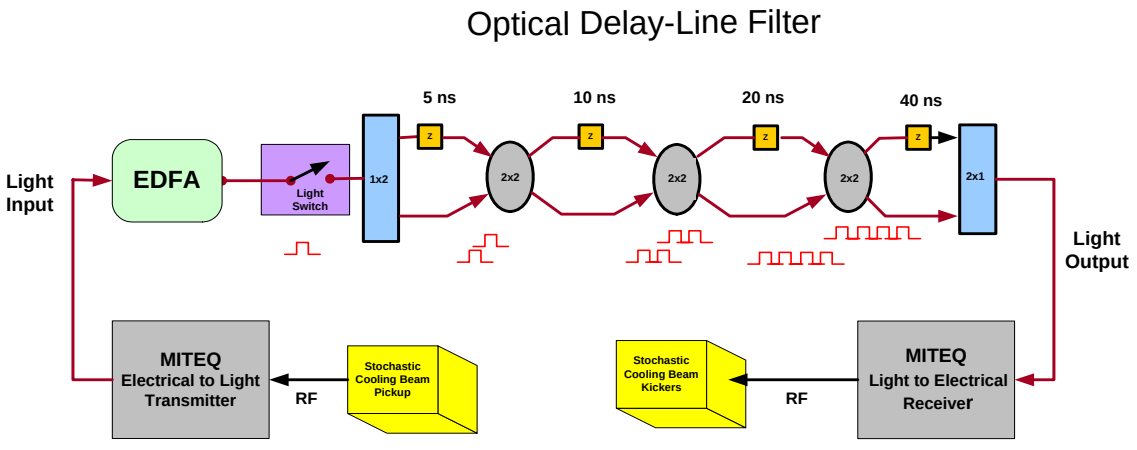


Figure 1. Components of optical delay line filter. Input and output are 1550 nm light.

# DEVELOP CONTROLS
# IDENTIFY ES&H STANDARDS

Recognition, evaluation, and control of laser hazards are governed by the following documents.

**American National Standards Institute (ANSI) Standard for Safe Use of Lasers;**
(ANSI Z136.1-2000)

**Laser Safety Subject Area**

**Brookhaven National Laboratory Environment Safety and Health Standard: 1.5.3 INTERLOCK SAFETY FOR PROTECTION OF PERSONNEL**

## ENGINEERING CONTROLS

| | | |
|---|---|---|
| ☐ Beam Enclosures | ☐ Protective Housing Interlocks | ☒ Other |
| ☐ Beam Stop or Attenuator | ☒ Key Controls | |
| ☒ Activation Warning System | ☐ Other Interlocks | |
| ☐ Ventilation | ☐ Emission Delay | |

Describe each of the controls in the space provided below this text. Interlocks and alarm systems must have a design review and must be operationally tested every six months. Controls incorporated by the laser manufacturer may be referenced in the manuals for these devices. **If any of the controls utilized in this installation requires a design review, a copy of the design review documentation and written testing protocol must be on file. Completed interlock testing checklists should be retained to document the testing history.**

Engineering Controls Description:

The Erbium-Doped Fiber Amplifier has a key operated on/off switch.

There is an audible alarm upon turn on of the amplifier.

When the system is operated the beam is totally enclosed in optical fiber and components. There is no open optical path.

## ADMINISTRATIVE CONTROLS

☐ Laser Controlled Area ☐ Signs ☒ Labels ☐ Operating Limits

The format and wording of laser signs and labels are mandated by BNL and ANSI standards. Only the standard signs are acceptable. Standard signs are available from the BNL Laser Safety Officer.

All lasers must have a standard label indicating the system's wavelength, power, and ANSI hazard class. Required labels must remain legible and attached. The manufacturer should label commercial systems.

**Standard Operating Procedures (SOPs) are required for laser system operation, maintenance (including alignment), and servicing. The SOPs need only contain the information necessary to perform these tasks and identify appropriate control measures including postings and personal protective equipment. The BNL Laser Safety Officer must approve SOPs and copies should be available at the laser installation for reference and field verification of stated control measures.**

Administrative Controls Description:

The amplifier will only be operated when all output fibers are terminated. During cleaning or reconnecting fibers the amplifier will be shut down and the key will be controlled by the owner.

## CONFIGURATION CONTROL

A checklist must be developed for the purpose of verifying the placement and/or status of components that are used to mitigate hazards by configuration control. Examples include any protective housings, beam stops, beam enclosures, and any critical optics *(mirrors or lenses that could misdirect the beam and result in personnel hazard)*. Entries should also be included to ensure placement of required signs and labels and status of interlock verification. Completed checklists must be posted at the laser location. The checklist does not have to be redone unless there has been a system modification, extended shutdown, or change of operations.
See C-A OPM 8.4m

## PERSONAL PROTECTIVE EQUIPMENT

☐ Skin Protection ☐ Eye Wear

**Skin Protection**: For UV lasers or lasers that may generate incidental UV in excess of maximum permissible exposure (MPE) describe the nature of the hazard and the steps that will be taken to protect against the hazard.

**Eye Wear:** All laser protective eyewear must be clearly labeled with the optical density and wavelength for which protection is afforded. Eyewear should be stored in a designated sanitary location. Color - coding or other distinctive identification of laser protective eyewear is recommended in multi-laser environments. Eyewear must be routinely checked for cleanliness and lens surface damage.

1. For invisible beams, eye protection against the full beam must be worn at all times unless the beam is fully enclosed.
2. For visible beams, eye protection against the full beam must be worn at all times during gross beam alignment.
3. Where hazardous diffuse reflections are possible, eye protection with an adequate Optical Density for diffuse reflections must be worn within the nominal hazard zone at all times.
4. If you need to operate the laser without wearing eye protection against all wavelengths present, explain the precautions that will be taken to prevent eye injury.

_____

Define eyewear optical density requirements by calculation or manufacturer reference and list other factors considered for eyewear selection. The BNL Laser Safety Officer will assist with any required calculations.

| EYE WEAR REQUIREMENTS | | | | | |
|---|---|---|---|---|---|
| Laser System Hazard | Wavelength (nm) | Calculated Intra-beam Optical Density | Diffuse Optical Density* | NHZ** (meters) | Appropriate Eye Wear*** |
| EDFA | 1550 | 0.2 @ 500mW | NA | <20cm | |
| | | | | | |
| | | | | | |

* Diffuse ODs are calculated assuming a 600 second exposure, a viewing distance of 20 cm, perfect reflectivity, and viewing normal to the surface. The ODs required can decrease for more typical conditions in the laboratory.

**The Nominal Hazard Zone is that zone or distance inside which exists a hazard to the eye from a diffuse reflection (as well as direct or specularly reflected light) for the time specified, in this case, 600 seconds (10 minutes).

***Specified eyewear may not be the only possible option, but represents an approved choice; depending on other laser hazards present in the lab, other eyewear may be acceptable provided the optical densities are equivalent or greater than those required.

| EYE WEAR SPECIFICATIONS | | |
|---|---|---|
| Laser System Eyewear Identification | Wavelengths | Optical Density |
| | | |
| | | |
| | | |

At an assumed numerical aperture(NA) of 0.1, and a maximum continuous output of 500mW, the resultant irradiance at a distance of 10 cm would be approximately 150mW mW/cm$^2$. The maximum permissible exposure at 1550nm is 1J/cm$^2$, for 10 sec. or 0.1W/cm$^2$ regardless of the exposure time so, in theory, one could be exposed at this level for 7 seconds. Since this is less than the 10 second assumed staring time, one would need to account for protective actions to mitigate this. According to Fiber Instrument Sales, Inc., the actual NA of the output fiber is about 0.14 which would actually double the allowable exposure time.

# TRAINING

## LASER SAFETY TRAINING

Laser Operators must complete sufficient training to assure that they can identify and control the risks presented by the laser systems they use. Owners/Operators and Qualified Laser Operators must complete the awareness level BNL World Wide Web based training course (TQ-LASER) every two years.

Qualified Laser Operators must also complete system-specific orientation with the system owner/operator. **System-specific training must be documented with a checklist that includes**

- Trainee name and signature
- Owner/Operator signature
- Date
- Brief list of topics covered e.g.,
  - Review of SOPs;
  - Review of working procedures, and other program specific documentation.

*All laser safety training must be repeated every two years.*

See BTMS

# C-A OPM 8.4m Configuration Control Checklist

1.____ All fiber connections are mated and terminated
2.____ All connector shutters are intact.

Operators Name: (print)_____ date:_____

Signature:_____